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91164

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NZQA

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Level 2 Chemistry, 2016

91164 Demonstrate understanding of bonding, structure, properties and energy changes

9.30 a.m. Monday 21 November 2016
Credits: Five

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of bonding, structure, properties and energy changes.	Demonstrate in-depth understanding of bonding, structure, properties and energy changes.	Demonstrate comprehensive understanding of bonding, structure, properties and energy changes.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

A periodic table is provided on the Resource Sheet L2–CHEMR.

If you need more room for any answer, use the extra space provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2–10 in the correct order and that none of these pages is blank.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

Excellence

TOTAL 23

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QUESTION ONE

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(a) Instant cold packs are useful for treating sports injuries on the field. They contain salts such as ammonium nitrate, NH_4NO_3. When the packs are activated, the salt dissolves in water, causing the temperature to decrease.

Circle the term that best describes the dissolving process.

endothermic **exothermic**

Give a reason for your choice.

The cold packs absorbs heat energy from surroundings

(b) The equation for hydrating anhydrous copper sulfate is as follows:

$$CuSO_4(s) + 5H_2O(\ell) \rightarrow CuSO_4.5H_2O(s) \qquad \Delta_r H^\circ = -78.2 \text{ kJ mol}^{-1}$$

Circle the term that best describes this reaction.

endothermic **exothermic**

Give a reason for your choice.

The enthalpy value is negative which means energy is being released.

(c) Pentane, C_5H_{12}, is a liquid at room temperature. It evaporates at 36.1°C in an endothermic process.

(i) Explain why the evaporation of pentane is an endothermic process.

The evaporation process is endothermic because the particles in the pentane liquid require heat energy to overcome the weak intermolecular forces between the molecules, ~~and therefore~~ The energy absorbed gives the particles more kinetic energy to break the ~~bonds~~, weak attractions.

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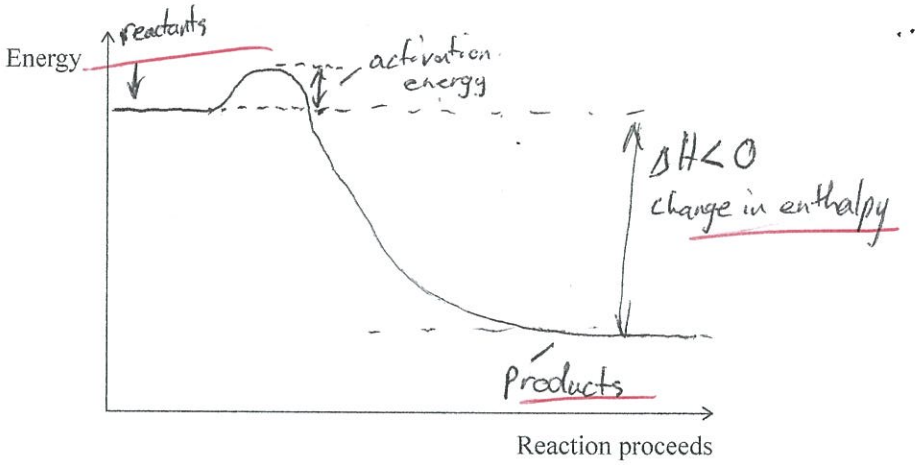
(ii) Draw, including labels, the energy diagram for the combustion of pentane, $C_5H_{12}(\ell)$.

Pentane combustion:

$$C_5H_{12}(\ell) + 8O_2(g) \rightarrow 5CO_2(g) + 6H_2O(\ell) \qquad \Delta_r H^\circ = -3509 \text{ kJ mol}^{-1}$$

Include in your diagram the reactants, products, and change in enthalpy.



(iii) Hexane, C_6H_{14}, like pentane, will combust (burn) in sufficient oxygen to produce carbon dioxide gas and water.

Hexane combustion:

$$2C_6H_{14}(\ell) + 19O_2(g) \rightarrow 12CO_2(g) + 14H_2O(\ell) \qquad \Delta_r H^\circ = -8316 \text{ kJ mol}^{-1}$$

Justify which alkane – pentane or hexane – will produce more heat energy when 125 g of each fuel is combusted in sufficient oxygen.

$M(C_5H_{12}) = 72.0 \text{ g mol}^{-1}$ $M(C_6H_{14}) = 86.0 \text{ g mol}^{-1}$

1 mol pentane ⟶ $-3509 \text{ kJ mol}^{-1}$

2 mol hexane ⟶ $-8316 \text{ kJ mol}^{-1}$

$n = \frac{m}{M}$ $n = \frac{125}{72}$ ~~$n = 15.625 \text{ mol}$~~ $n = 1.736 \text{ mol}$

1 ⟶ −3509

1.736 ⟶ ΔH

~~$\Delta H = 54828.125 \text{ kJ mol}^{-1}$~~

~~pentane = 54,800 kJ~~

pentane = 6092 kJ

= 6090 kJ

energy released

$n = \frac{m}{M}$ $n = \frac{125}{86}$ $n = 1.45 \text{ mol}$

2 ⟶ 8316

1.45 ⟶ E

$E = 6043.6 \text{ kJ}$

hexane = E = 6040 kJ energy released

Pentane has more energy released than Hexane

6090 kJ > 6040 kJ

E8

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QUESTION TWO

(a) Complete the table below by stating the type of substance, the type of particle, and the attractive forces between the particles in the solid for each substance.

Substance	Type of substance	Type of particle	Attractive forces between particles
$ZnCl_2(s)$ (zinc chloride)	Ionic	Ion	Ionic bond
$C(s)$ (graphite)	Giant covalent network	atom	Strong covalent bonds
$CO_2(s)$ (carbon dioxide / dry ice)	Molecular	molecule	weak intermolecular forces

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(b) Carbon (graphite) conducts electricity when it is solid, whereas zinc chloride, $ZnCl_2$, will not conduct electricity when solid, but will conduct when molten.

Justify this statement in terms of the particles, structure, and bonding for both substances.

Graphite is a giant covalent network which is made up of carbon atoms (covalently) bonded to three others in a trigonal planar shape. There is one delocalised valence electron which bonds between the ~~layers~~ sheets. ~~This~~ These (delocalised) valence electrons are free to move and can therefore conduct electrical charge ~~through the whole~~ (through the) solid. //

$ZnCl_2$ is an ionic substance which is in the form of a 3D lattice while solid with alternating positive (Zn^{2+}) ions and negative (Cl^-) ions. These ions are held together by strong electrostatic attractions and cannot move. This is why $ZnCl_2$ cannot conduct electricity while solid. When $ZnCl_2$ is a liquid or in solution, the ions are free to move about and can transfer electrical influence through the substance. //

C

(c) Solid zinc chloride, $ZnCl_2(s)$, is soluble in water. Dry ice, $CO_2(s)$, is not readily soluble in water.

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Justify these statements in terms of the particles, structure, and bonding of these substances.

You may include a diagram or diagrams in your answer.

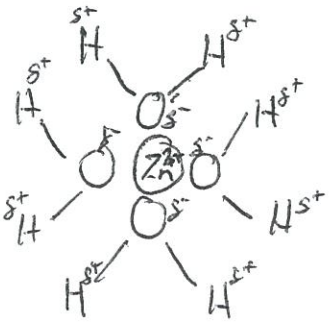
$ZnCl_2$ is an ionic substance. When in solution, the polar water molecules can interact with the ions pulling them apart. The δ^+ H atom attracts the Cl^- ion and the δ^- O atom attracts the Zn^{2+} ion. Therefore $ZnCl_2$ is soluble in water.

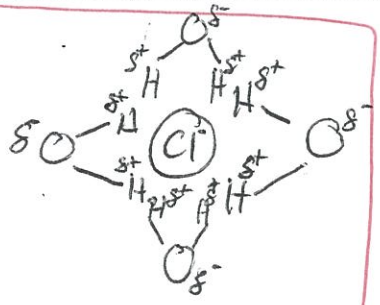
CO_2 is a molecular substance which is held together by weak intermolecular forces. CO_2 is a non-polar molecule due to its symmetrical nature and does not split apart into ions when in solution. The polar water molecules cannot interact with the molecule so CO_2 will not readily dissolve in water.

4

Space for diagrams

Solid $ZnCl_2$





dissolved in H_2O

E7

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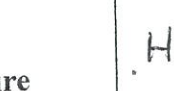
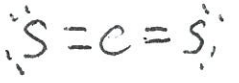
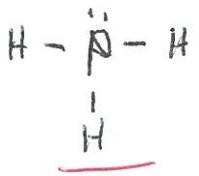
QUESTION THREE

(a) (i) Draw the Lewis structure (electron dot diagram) for each of the following molecules, and name their shapes.

Molecule	H_2O	CS_2	PH_3
Lewis structure			
Name of shape	Bent	linear	Trigonal pyramidal
Approximate bond angle around the central atom	109.5°	180°	109.5°

(ii) Compare and contrast the shapes and bond angles of H_2O, CS_2 and PH_3.

H_2O has four regions of negative charge around the central O atom which repel for maximum separation into a tetrahedral shape with bond angles of about 109.5°. There are two bonding regions and two non-bonding regions so the overall shape is Bent. ||
PH_3 is similar to H_2O in that there are four regions of negative charge around the central P atom. They repel for maximum separation into a tetrahedral shape with bond angles of about 109.5°. However, PH_3 has three bonding regions and 1 non-bonding region so the overall shape is Trigonal pyramidal. ||
CS_2 has two regions of negative charge around the central C atom which repel for maximum separation into a linear shape with bond angles of 180°. Both regions are bonding regions so the overall shape is linear. ||

(b) The Lewis structures for two molecules are shown.

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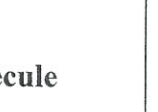
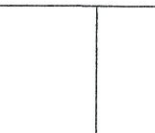
Molecule	 Ammonia	 Borane
Polarity of molecule	polar	non-polar

Ammonia, NH_3, is polar, and borane, BH_3, is non-polar.

Justify this statement.

Ammonia has four regions of negative charge around the central N atom. Three of these are bonding regions and 1 is non-bonding. The overall shape is trigonal pyramidal with bond angles of 109.5°. There are three polar N-H bonds because N is more electronegative than H. The NH_3 molecule is asymmetric so the effects of the bond dipoles ~~cancel~~ do not cancel and the molecule is therefore polar.

BH_3 has three areas of negative charge which repel for maximum separation around the central B atom. All regions are bonding regions so the overall shape of BH_3 is trigonal planar with bond angles of 120°. There are 3 polar B-H bonds due to the difference in electronegativity. The BH_3 molecule is symmetrical so the effects of the bond dipoles cancel and BH_3 is overall non-polar.

C

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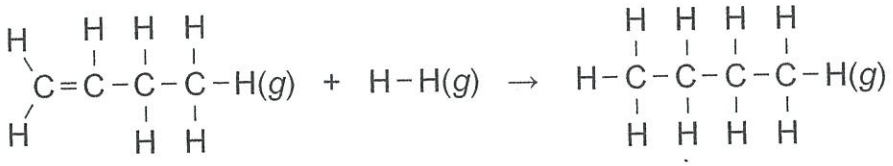
(c) Calculate the enthalpy change, $\Delta_r H^\circ$, for the reaction of but-1-ene gas, $C_4H_8(g)$, with hydrogen gas, $H_2(g)$, to form butane gas, $C_4H_{10}(g)$.

Use the average bond enthalpies given in the table below.



Bond	Average bond enthalpy / kJ mol^{-1}
C=C	614
C–C	346
C–H	414
H–H	436

Show your working and include appropriate units in your answer.

$\Delta_r H^\circ = \Sigma$ E bonds broken $- \Sigma$ E bonds formed.

$\Delta H = (614 + 436) - 2(414) + 346$

$\Delta H = 1050 - 828 + 346$

~~1174~~ $1050 - 1174$

$\Delta_r H^\circ = -124$ kJ mol^{-1} (1)

C

E8

Annotated Exemplar

Excellence exemplar 2016

Subject:	Chemistry	Standard:	91164	Total score:	23

Q	Grade score	Annotation
1	E8	Both parts (a) and (b) are correct. Heat energy absorbed and intermolecular bonds in part (c)(i) are correct. In part (c)(ii), the graph is drawn correctly and is fully labelled. The energy calculations are correct and an appropriate conclusion is given in (c)(iii).
2	E7	The table is correct in part (a). Conductivities of both graphite and $ZnCl_2$ are justified in part (b). In part (c), the attractions are included for $ZnCl_2$ but the response does not refer to the relative strengths of the attractions. Also it is stated that H_2O and CO_2 cannot interact.
3	E8	The table is correct in part (a)(i). The shapes are correctly explained in (a)(ii). The candidate's response about PH_3 demonstrates both a comparison and a contrast. In part (b), the electronegativity difference between B and H is holistically inferred for BH_3. The calculation is correct in part (c).